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DEVELOPMENT OF MILITARY PERFORMANCE MODELS  
FOR THE ASSESSMENT OF PSYCHOPHARMACOLOGICAL AGENT IMPACT

ANNUAL SUMMARY REPORT

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<p>In time of war, the human operators of military systems may be exposed to harmful psychopharmacological agents. Certain pretreatment drugs are known to ward off the harmful effects of chemical agents, but these drugs have adverse side effects that may degrade a soldier's ability to perform an operation. This report describes the development of a task network modeling tool which will be used to simulate the effects of drugs on human performance.</p> <p>This simulation tool is known as Micro SAINT. It is a software package that runs on an IBM PC (International Business Machines, Boca Raton, Florida) or compatible microcomputer. Micro SAINT was designed to be easy to learn and easy to use, so that building models does not require the services of a simulation expert. Several examples are given in which this system was used in real situations. <i>Keywords:</i></p>					
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## SUMMARY

The charter of this contract is to assist in the development of computer models to evaluate the effects of chemicals on the human operators of military systems (tanks, helicopters, artillery, etc.). This report describes the work performed by Micro Analysis and Design during the first year of the contract. A software package known as Micro SAINT was developed to easily build and execute computer models. This package runs on an IBM PC or compatible microcomputer. Its important features are described in the body of the report. More detailed information may be found in the Micro SAINT User's Guide. Further improvements need to be made before Micro SAINT is complete, and then it will be available as an easy-to-use modeling tool.



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## FORWARD

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# **1. Statement of the Problem**

The Statement of Work for this contract calls for us to develop a tool that will enable research scientists to simulate the effects of psychopharmacological agents on the human operators of military equipment, such as tanks and helicopters.

## 2. Background

To model human operators, we used the methodology provided by the simulation language SAINT (Systems Analysis of Integrated Networks of Tasks). SAINT uses task network modeling to represent the activities of a human operator. The problem with SAINT is that it is difficult to master the techniques required to build useful models, in part because it requires the model builder to program in FORTRAN. It also requires a mainframe computer. We decided to develop a microcomputer version of SAINT that would be easy to use—a simulation tool that would require no previous training in simulation or computer programming. This report describes our progress in developing Micro SAINT.

Section 3 is a discussion of the Micro SAINT software itself, including the technical specifications and two features which set it apart from other simulation languages. Section 4 describes the documentation needed to operate the software. Section 5 describes several real applications in which Micro SAINT has been used.

### 3. The Software

The Micro SAINT software package runs on an IBM PC (International Business Machines, Boca Raton, Florida) or compatible computer. There are currently 15,315 lines of source code, written in the C language. These make up the four main Micro SAINT application programs: Develop, Execute, Analyze, and Printout. Each program handles one phase of the modeling process. Accompanying the programs are 86 Help screens and some sample models. The entire package resides on three floppy diskettes.

The driving force behind the design of Micro SAINT has been to make it easy to learn and easy to use. We chose to implement a menu-driven user interface with this objective in mind. All operation of Micro SAINT is by menus: The user makes a selection from a list of choices, rather than memorize complicated commands or master the syntax of a programming language. Three types of menus are needed: a list of choices, a list of data "objects," and data object fields. Examples of these three types are shown in Figures 1, 2, and 3.

First, we tested the software in-house, then with novice users. It takes about 2 days of training for someone to become proficient at modeling with Micro SAINT. Our chosen methodology of task network modeling (similar to flowcharts) is an effective way for subject matter experts to describe the sequence of steps involved in completing a job.

The Execute program has a feature called a parser, which greatly increases the modeling power of Micro SAINT. A parser is a program which interprets algebraic expressions and calculates a numeric result. There are a number of places in Micro SAINT where an expression can be used instead of a number--for example, the time to complete a task. Under normal conditions a task may take, for example, 20 seconds on the average. But if the human operator is fatigued, or has taken a drug to ward off the effects of a chemical agent, the mean time will probably be greater. If the person conducting the simulation experiment can write an algebraic expression for the mean time in terms of the drug dosage and fatigue level, this expression can be used instead of the number 20. The parser allows models to be dynamic, that is, to change their characteristics as the simulation experiment progresses.

The mathematical operators that Micro SAINT recognizes are shown in Figure 4. The built-in functions are shown in Figure 5.



#### 4. The Documentation

If Micro SAINT is to gain wide acceptance, it must have quality documentation to go with the software. There are two parts to the documentation--the help screens and the manual. The help screens provide answers to the user's questions as he or she builds a model. At any point in the software, typing "help" produces a specific explanation of what is currently happening. We began writing the text for the help screens in April 1985 and completed all 86 screens several months later. They contribute greatly to the ease of use of Micro SAINT.

The second part of the documentation is the Micro SAINT User's Guide. It is roughly 200 pages long, and begins with a tutorial introduction which leads the beginning user through the entire process of building a model. After the introduction there are sections describing each of the four main programs. The next section lists all Micro SAINT error messages, and tells what to do if one appears. Following this are the glossary of terms and the index. The manual is written to be understood by someone with no previous simulation experience.

Although the Micro SAINT User's Guide thoroughly describes how to operate the software, it does not attempt to tackle the larger issue of how to model a real situation. To teach techniques which are better gained through experience and discussion than through reading a manual, we have designed a 2-day training seminar on modeling with Micro SAINT. We gave this seminar in July 1985 in Washington, DC, and in October at Fort Rucker, AL.

## 5. Applications

The first real application of Micro SAINT occurred in February 1985, when we showed the package to a group of noncommissioned officers from a U.S. Army Armored division in Fort Knox, KY. The M60 tank has a four-man crew, and the tank operators described to us the sequence of voice commands, responses, and actions that take place between the time a target is spotted and when a shot is actually fired. We built a model of the firing sequence and returned to Fort Knox in April to check its correctness. In a follow-up session with the tank operators, we made a few revisions and included some special cases. The final model drawing is shown in Figure 6. The Micro SAINT software and tank model were delivered to the Advanced Technology Research Division, which has acquired a microcomputer for the purpose of modeling.

In April 1985 we began a 3-month modeling project with Texas Instruments in Dallas, Texas. The ARTI (Advanced Rotorcraft Technology Integration) program there is working on the cockpit design for the Army's new LHX helicopter. This is to be a one-man helicopter, and they are determining whether a single pilot can handle the same workload that is now handled by a pilot and a copilot. We simulated a combat mission that involved entrance into the enemy zone, several combat engagements, egress from the zone, and battle damage assessment. The models we built for this project were much larger than the tank model; the largest one had 250 tasks. Figure 7 shows the overall network and Figure 8

shows the subnetwork representing Target Engagement. We plotted variables representing the demands on the pilot's attention over the course of the mission, and were able to show that the LHX concept is workable, provided that an automated cockpit is used.

In September 1985 we began work on a modeling project at Fort Rucker, AL. where U.S. Army helicopter pilots are trained. The trainees go through a 6-week program which involves both classroom instruction and in-flight practice. Our task is to determine the amount of resources required throughout the course schedule, as well as to model the skill acquisition of a student pilot. The resource model currently has about 400 tasks. This effort is scheduled to be completed in December 1985.

## 6. Discussion and Conclusions

Although Micro SAINT is now a useful tool, it is not complete. The current version of the software is designated Release 2.0. We are working on a number of enhancements to this release to alleviate problems that our users have noted. Release 2.1 of the software is scheduled to be completed on March 1, 1985. This new version will be similar to the present version, but will have some additional features.

Users of Micro SAINT have requested a number of more powerful features that would assist them in the overall modeling process. Typically a modeling effort begins by drawing a task network on a piece of paper. As this model is revised during the design process, it is difficult to keep these drawings up to date. Diagrams are an important part of a model's documentation, because they enable users to visualize the sequence of events. Task networks could be drawn on the computer screen by the software itself, and then sent to a printer. This feature would alleviate the time-consuming job of drawing networks by hand. Furthermore, networks could be constructed by the model builder with the aid of a mouse, in the same way that a mechanical engineer designs parts with a CAD/CAM system.

In November 1985 we visited the Army Medical Research Laboratory at Wright-Patterson Air Force Base, OH., to see how our work could fit in with that of the other members of the Joint Working Group. Dr. Robert Mills is currently working on modeling with IDEF on a Micro-VAX workstation. There may be a way for our two systems to reside on the same computer and share data between them, so that the entire modeling process can be carried out on this single workstation. We will meet again in the next few months to explore this possibility further.

## INTERACTIVE MODEL DEVELOPMENT

- (1) Current Model Name In Memory: example
  - (2) Task Network
  - (3) Variable Catalog
  - (4) Function Library
  - (5) Continuous Variable Changes
  - (6) Simulation Scenario
  - (7) Snapshots of Execution
- Memory Available - 408488 bytes

Aspect of model development to work on (1-7)?

Figure 1. List of Choices

Add Modify Delete Copy Save

NETWORK LISTING

Model: example

Number:	Name:	Type:
1	get widget	Task
2	process widget	Task
3	done	Task

Command (a,m,d,c,s)?

Figure 2. List of Data Objects

## MODIFY TASK

Task Number: 1

- |                                   |                |
|-----------------------------------|----------------|
| (1) Name: Get widget              | (2) Type: Task |
| (3) Upper Network: 0 example      |                |
| (4) Release Condition: 1;         |                |
| (5) Time Distribution Type: Gamma |                |
| (6) Mean Time: 2;                 |                |
| (7) Standard Deviation: .5        |                |
| (8) Task's beginning effect:      |                |
| (9) Task's ending effect:         |                |
| (10) Decision Type: Probabilistic |                |

Following Task/Network:		Probability of Taking
Number:	Name:	This Path:
(11) 2	Process widget	(12) widgets > 0;
(13) 3	Done	(14) widgets == 0;
(15)		(16)
(17)		(18)
(19)		(20)
(21)		(22)
(23)		(24)

Number of the field to change?

Figure 3. Data Object Fields

## Micro SAINT Expressions

### Mathematical Operators

- ()** Grouped Operations
- ^** Exponentiation
- \*** Multiplication
- /** Division
- %** Remainder Division
- Subtraction
- +** Addition

### Logical Operators

- >** Greater than
- <** Less than
- >=** Greater than or equal to
- <=** Less than or equal to
- <>** Not equal to
- |** Logical OR
- &** Logical AND
- ==** Equal to
- =** Assignment

### Logical Statements

**if**  
**then**  
**else**

Figure 4. Micro SAINT Operators

### Micro SAINT Functions

<b>sin(angle)</b>	<b>sine of an angle, in degrees</b>
<b>cos(angle)</b>	<b>cosine</b>
<b>tan(angle)</b>	<b>tangent</b>
<b>arcsin(value)</b>	<b>angle whose sine is value</b>
<b>arccos(value)</b>	<b>arccosine</b>
<b>arctan(value)</b>	<b>arctangent</b>
<b>abs(number)</b>	<b>absolute value</b>
<b>rand()</b>	<b>random number between 0.0 and 1.0</b>
<b>dist(x1,y1,x2,y2)</b>	<b>distance between two Cartesian points</b>
<b>dir(x1,y1,x2,y2)</b>	<b>direction from one point to another</b>
<b>ln(number)</b>	<b>natural logarithm</b>
<b>log(number)</b>	<b>log to the base 10</b>

**Figure 5. Micro SAINT Functions**



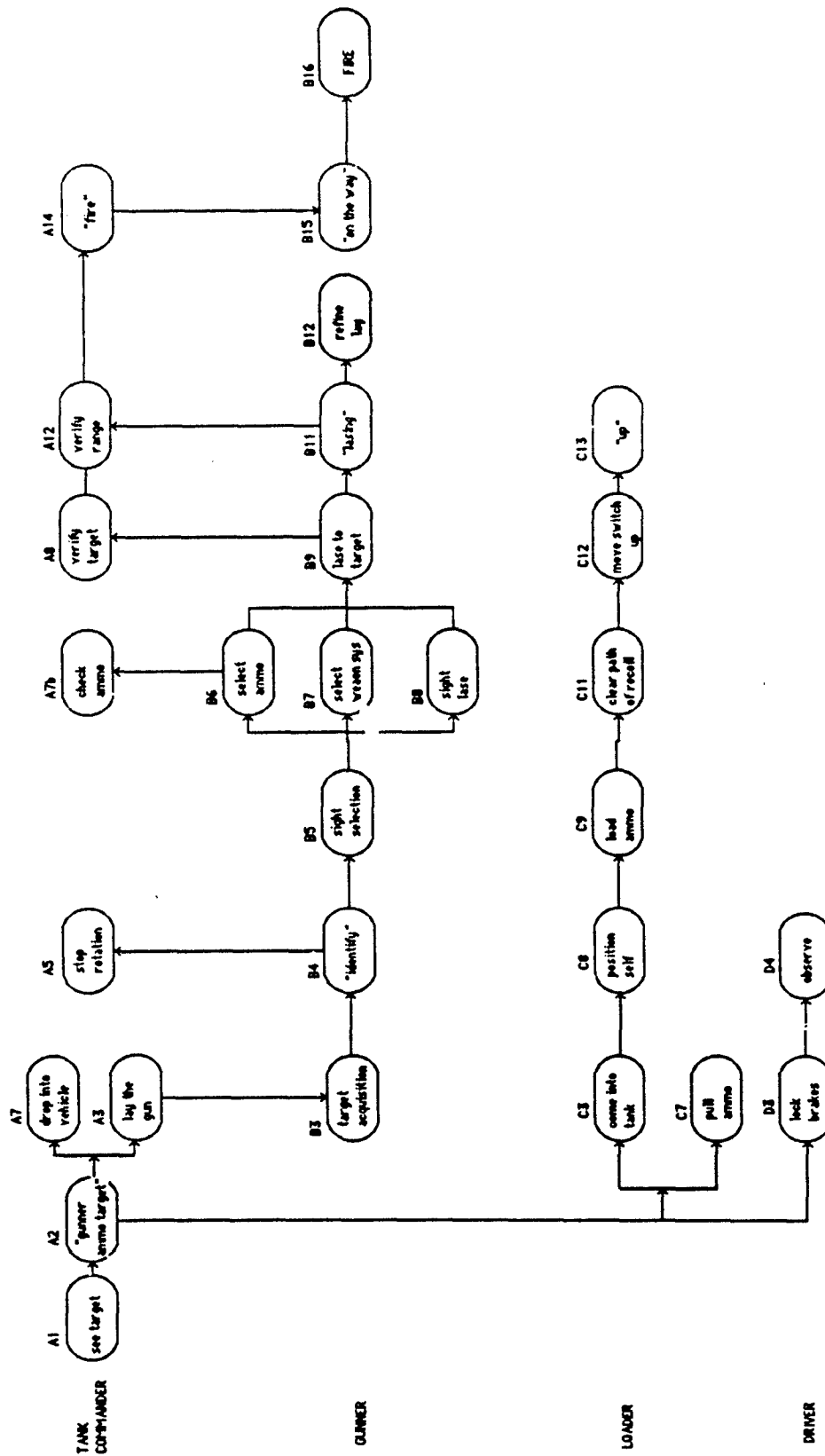


Figure 6. M60 Tank Model

# GENERIC LHX

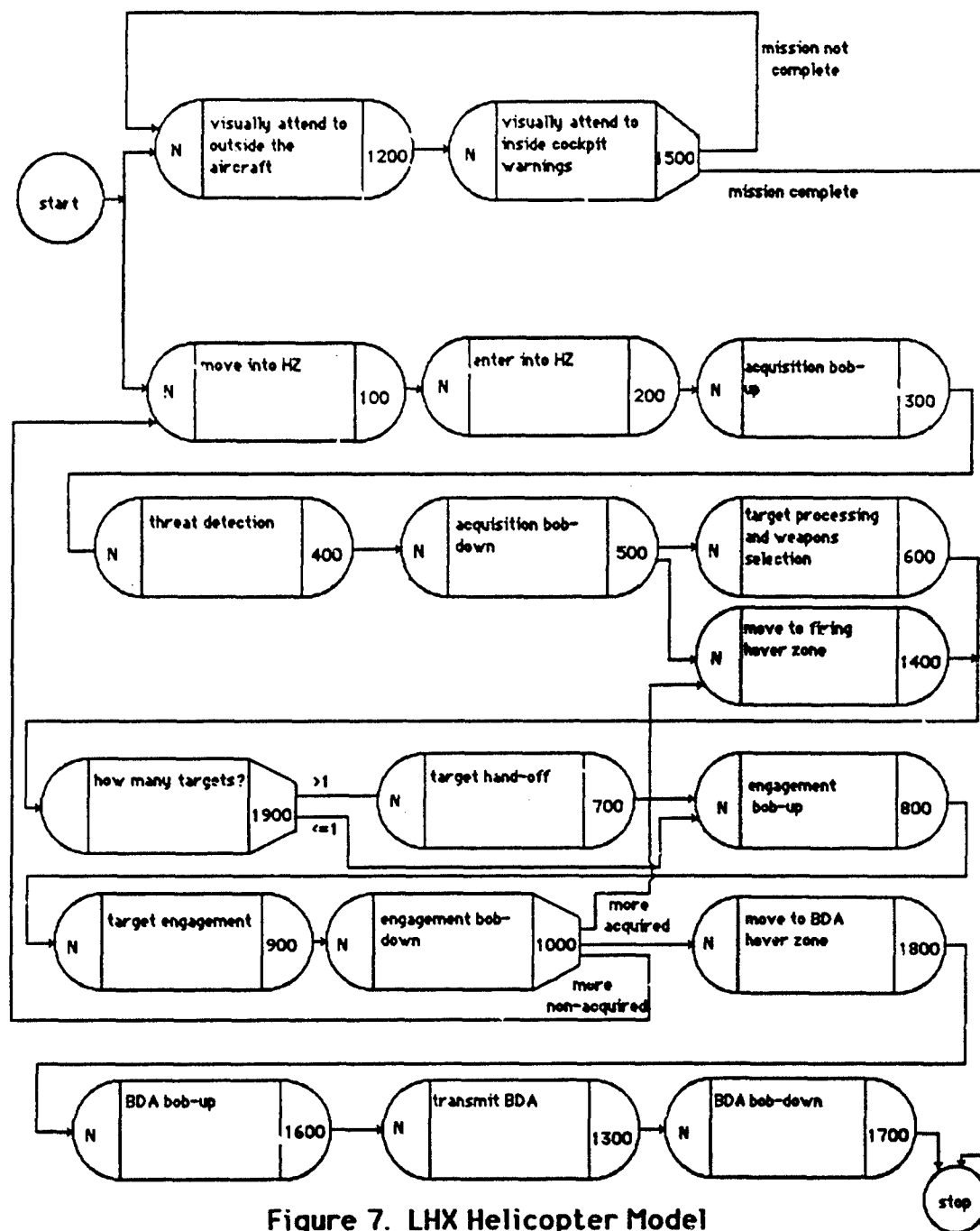


Figure 7. LHX Helicopter Model

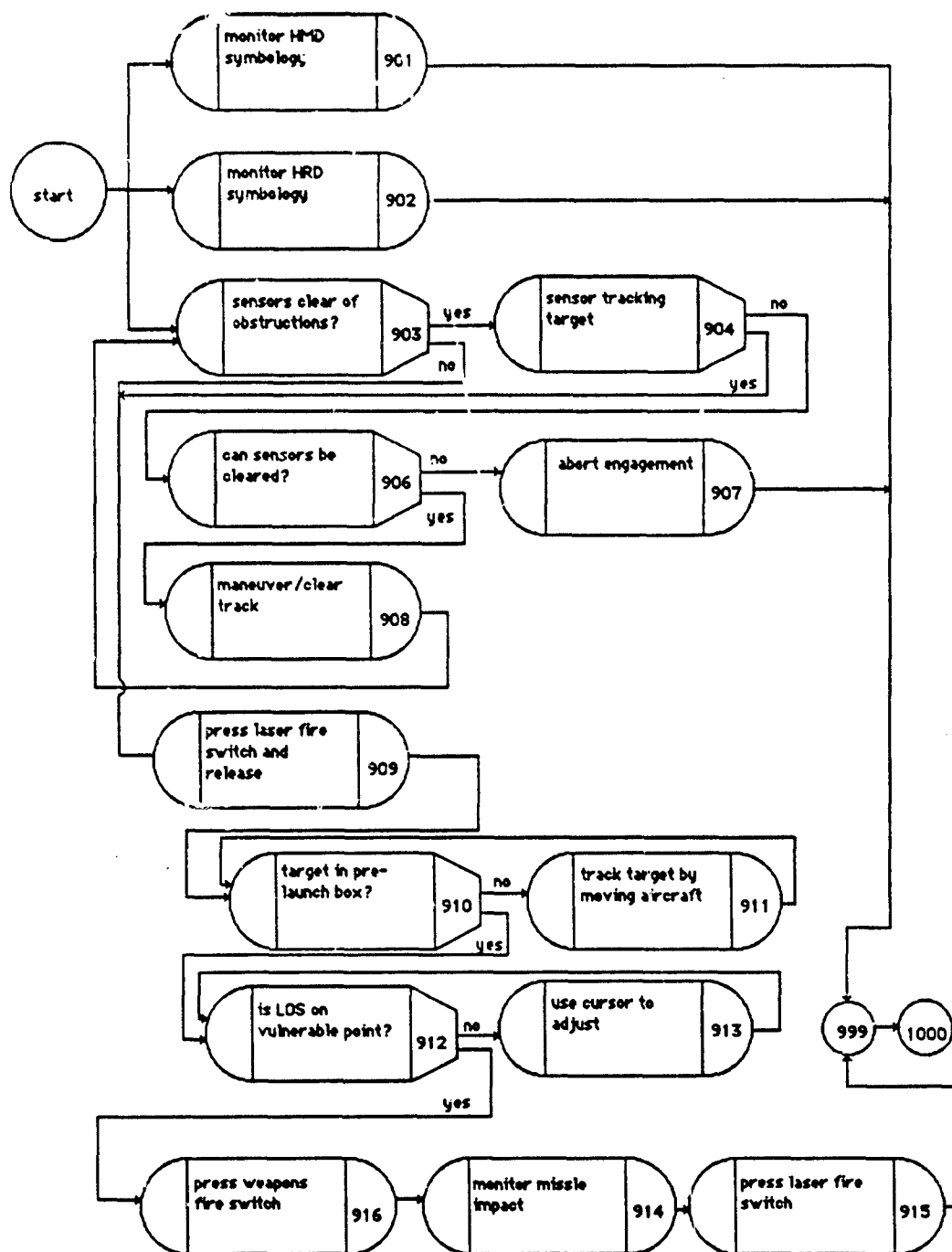


Figure 8. LHX Target Engagement

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